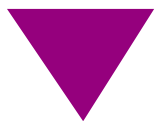




# Strategy for Continuous PM Mass Monitoring

Presentation to CASAC  
Subcommittee on Particle Monitoring  
January 28, 2002

Emissions Monitoring and Analyses Division  
EPA - Office of Air Quality Planning and Standards



# Topics

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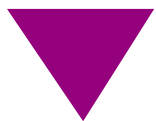
- Objectives of this strategy
- Applicability of this strategy
- Background/Motivation
- Implementation Options
- Method Applicability
- Resource Requirements for an example Network
- PM<sub>2.5</sub> Continuous Monitoring Analyses
- PM Continuous Methods Summary
- PM Continuous Monitoring Strategy Summary



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# Continuous PM Monitoring Strategy Objectives

- Network:
  - Create a "hybrid" network of filter based and approved continuous monitors to achieve multiple monitoring objectives
    - A few hundred FRMs
      - Implies divestment
    - Several hundred Continuous Monitors
      - Implies investment
- Method Performance Criteria:
  - Utilize Data Quality Objective (DQO) Process to define performance criteria
    - Account for improvements in sample frequency when considering PM continuous method in place of filter methods - Effective daily sample instead of 1 in 3 day or 1 in 6 day sample schedule.
- Method Approval:
  - Create provisions for rigid and flexible approval of methods
    - Rigid approval for methods that are used for monitoring objectives to include NAAQS decisions
    - Flexible approval when methods are to be used for all monitoring objectives other than NAAQS



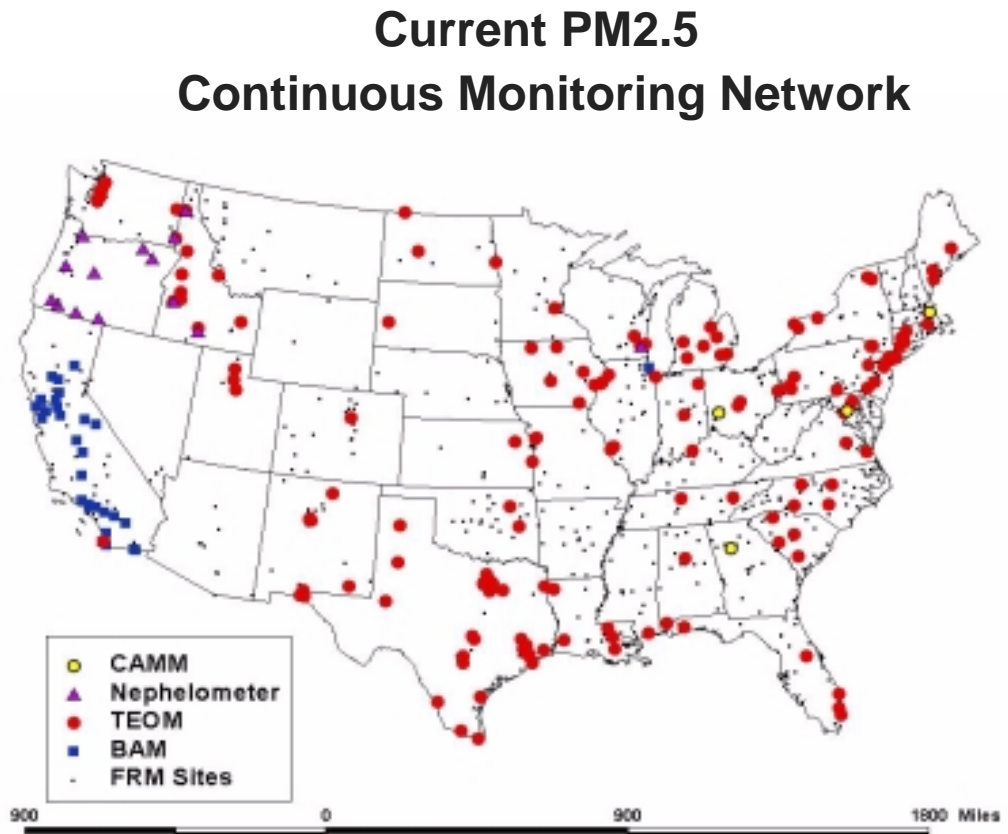
# Applicability of this Strategy

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- PM2.5
  - Yes - This strategy specifically applies to PM2.5.
    - FRM as *reference method*
- PM coarse
  - Yes - Although a reference monitoring method for PM coarse (PM10 - PM2.5) is not currently defined, the concepts and flexibility presented in this strategy are intended to apply to potential PM coarse monitoring needs.
- PM10
  - No - Do not intend to use this strategy to promote or approve of continuous monitors on a regional basis for PM10.

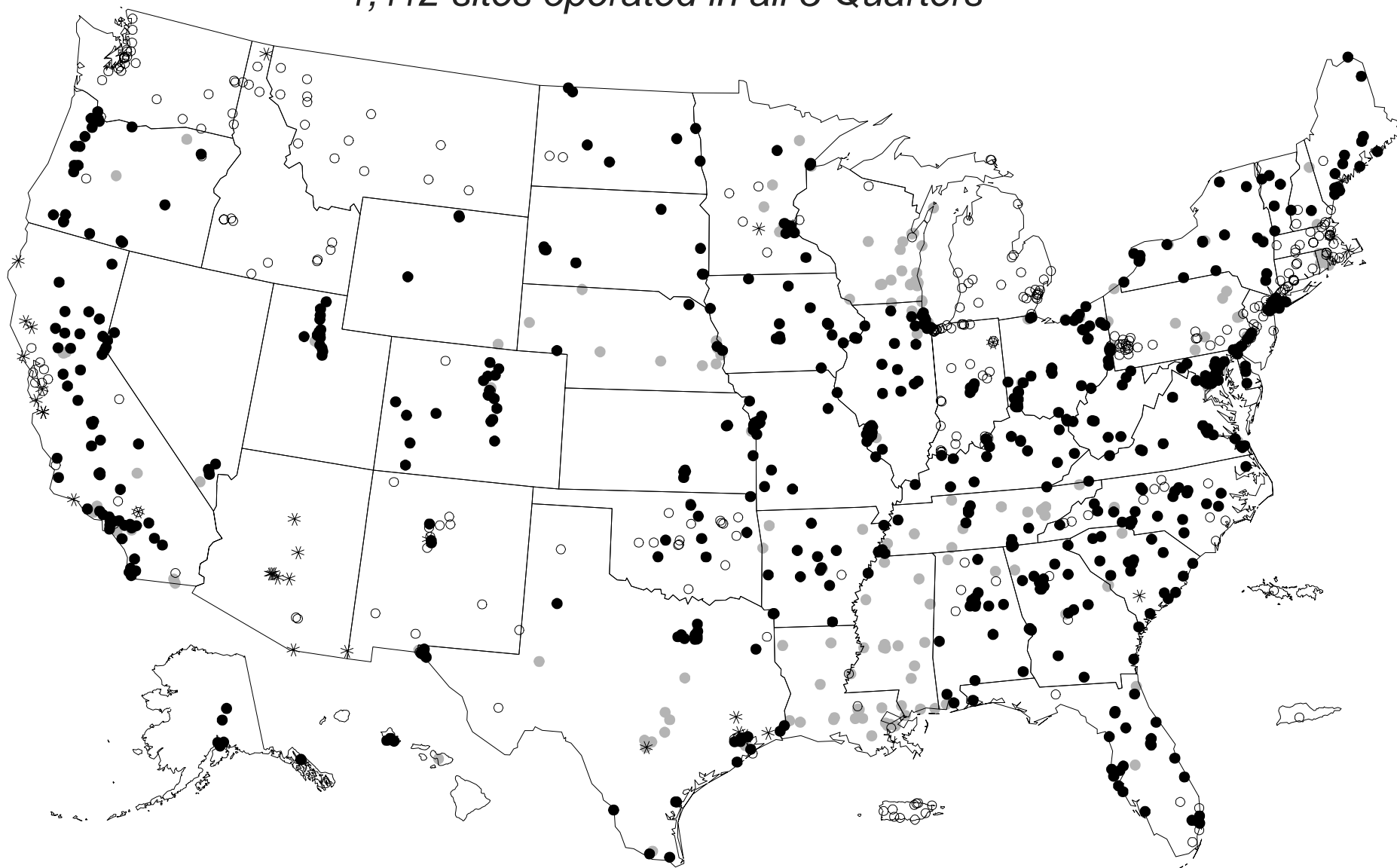
# Background/Motivation

- Large network of FRMs with limited data use versus relatively small network of PM2.5 continuous monitors with potential for many data uses:
  - 1112 FRM sites operational in '01
  - ~200 PM2.5 Continuous monitors operational in '01
- Reduce operator burden associated with filter based methods
  - major request from STAPPA/ALAPCO
  - implies FRM reduction through monitoring strategy/assessments
- CASAC Particle Monitoring Subcommittee has specifically requested that this be addressed



# 2001 PM2.5 FRM Data Completeness

*1,112 sites operated in all 3 Quarters*



*[Based on AIRS data  
entered through  
12/20/01]*

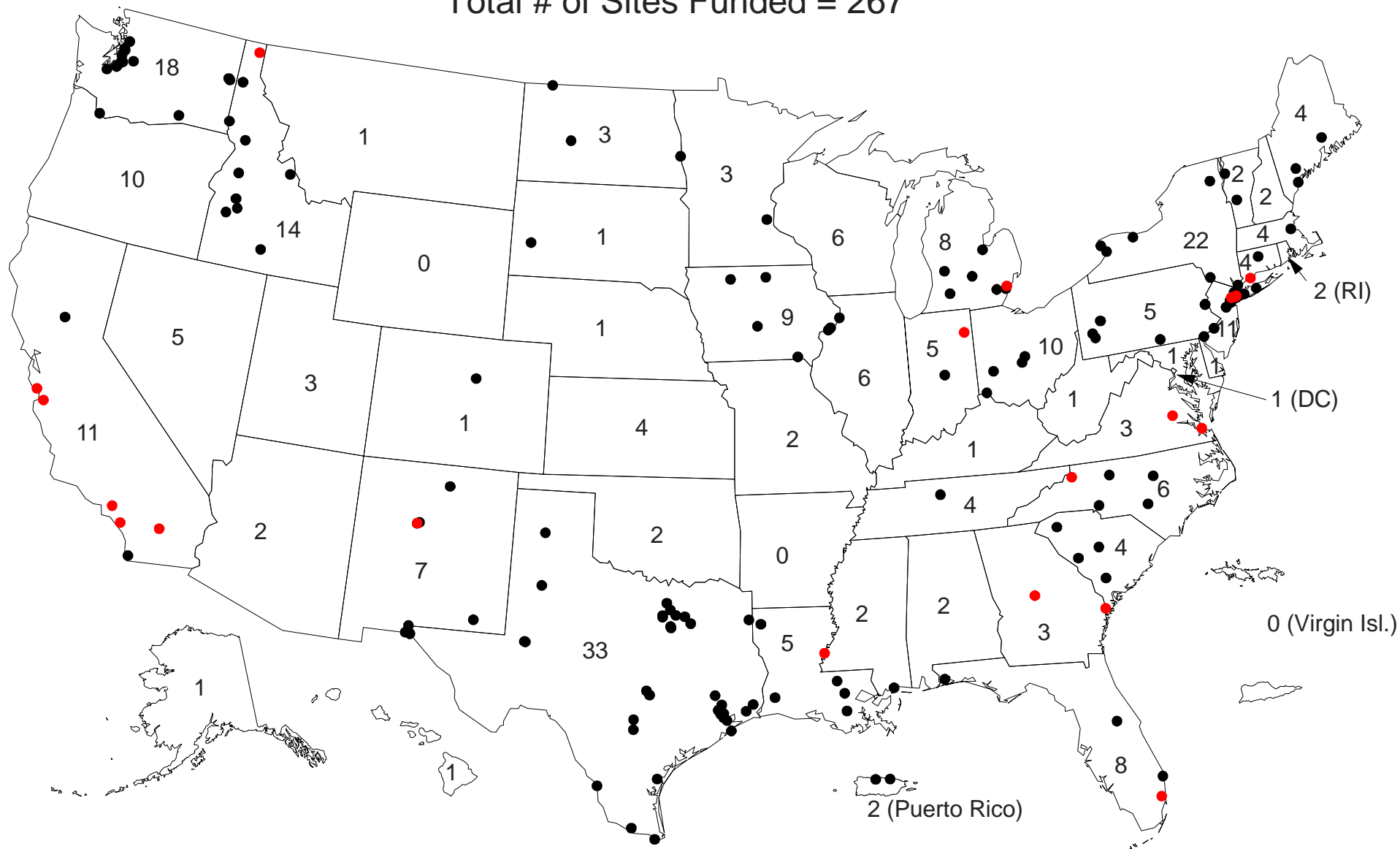
- Sites with Q1, Q2, and Q3 "complete" (75% or better) [578]
- Sites with 11+ samples in each Quarter (but not 75% in all) [181]
- Other sites with data [306]
- \* Sites with no data [47]

# Continuous PM<sub>2.5</sub> Monitoring Sites

Black = Data reported in AIRS (157)

Red = Site registered in AIRS but no data (19)

Total # of Sites Funded = 267\*



\* Based on AIRS data entered through 12/20/01.

Numbers of "funded" continuous sites are provided within each State outline for reference.



# Implementation Options - Network Design Elements

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- Retain minimum number of FRMs (*e.g. 30% of the required sites in each network*) to:
  - Provide the closest link possible to the historical health studies
  - Consistency with the currently deployed network of FRMs
  - Provide a baseline set of data for ongoing evaluation of the continuous monitoring technologies
  - Minimums apply to each monitoring agencies network
- Only allow continuous monitoring technologies into the network that meet performance specifications as defined in the DQO process
- Retain minimum number of total sites operating in hybrid network of FRM/FEMs and PM2.5 continuous monitors
  - *Total number of required sites to be reduced.*
    - Currently 850 required
    - Future ~600 being considered
- Mature Hybrid Network of FRM/FEMs and PM2.5 continuous monitors all meeting the DQOs goals for Precision and Bias can accomplish several monitoring objectives:
  - NAAQS, AQI, Mapping, Exposure, Model Evaluation



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# Implementation Options - Flexibility with Continuous Monitors

- What's being considered:
  - Two types of PM continuous monitors are being considered
    - Regionally Equivalent Monitors (REMs)
      - Can be used for all applicable monitoring objectives
    - Revising provision for Correlated Acceptable Continuous (CACs) Monitors
      - Have more flexibility in approval than REMs
      - Can be used for all applicable monitoring objectives, except NAAQS decisions
- Why two approaches?
  - REM - Need to have an approved PM continuous monitor that can be used to replace a portion of the FRMs in areas where the performance criteria are met.
  - CAC - Need to have a PM continuous monitor producing data with an expected level of quality where the REM will not work or is not needed.
    - Could replace a portion of the FRMs that are not needed for NAAQS; however, the data are used for other monitoring objectives
    - Enhanced sample frequency reductions



# Existing vs. New Paradigm to Approve PM Continuous Monitors

Topic	Existing FEM	New REM	New CAC
Spatial Scale of Approval	Nationally	By network - size can be flexible	By site or network of sites
Location of Test Sites	Specific areas required to be covered so as to include range of aerosol and environmental conditions	In the areas that the instruments are intended to be operated	In the areas that the instruments are intended to be operated
Field Testing	Generally rely on vendors to initiate	Empower State and local agencies to initiate	Empower State and local agencies to initiate
Performance Criteria for Approval	Requirements: Slope of 1 +/- 0.05 Intercept of 1 ug/m <sup>3</sup> Correlation of >=0.97	Requirements: Bias +/- 10% Precision 20% CV	Goals: Bias +/- 10% Precision 20% CV




# Generating Test Data for Acceptance of REM and CAC

	Geographical Area of Consideration	Number of Test Sites
REM	One MSA	2
	Multiple MSA's in the same air district or State	1 for each MSA up to the first 3 MSA's, plus at least one in a rural county
	Multiple States	1 for each MSA up to first 2 MSAs, plus at least 1 site in a rural county. For each additional State add 1 urban and 1 rural county
CAC	One site	1
	One MSA	2
	Multiple MSA's in the same air district or State	1 for each MSA up to the first 3 MSA's, plus at least one in a rural county
	Multiple States	1 for each MSA up to first 2 MSAs, plus at least 1 site in a rural county. For each additional State add 1 urban and 1 rural site

# PM Method Category Applicability

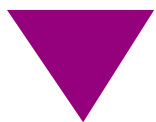
Method Category	<80% NAAQS Required Sites	80% to 120% of NAAQS Required Sites	>120% of NAAQS Required Sites	Sites that are currently required but not required in a future network	Current Supplemental Sites	Background and Transport Sites	Speciation and IMPROVE
FRM/FEM	✓	✓	✓	✓	✓	✓	
REM	✓ With 30% FRM collocation in network	✓	✓ With 30% FRM collocation in network	✓	✓	✓	
CAC	✓ With 100% FRM Collocation FRM operates 1 in 6		✓ With 100% FRM Collocation FRM operates 1 in 6	✓	✓	✓	
IMPROVE						✓	✓
Speciation						✓	✓
Existing Continuous mass PM					✓		

Items in **red** indicate a change to the monitoring regulation would need to be made



# Comparison of Current vs. Potential New PM2.5 Network

Specification or Monitoring Objective	Current Network	Potential future Network
Size of PM2.5 "Compliance" Network	~ 1100 FRMs	~600 Reference or Equivalent Monitors (FRM/FEM/REM) ~200 - 500 of these would be FRMs Balance would be REMs
Total size of PM2.5 Network (FRM and Continuous)	~ 1150 sites	~ 1000 sites The ~600 Reference or Equivalent Monitors (FRM/FEM/REM) and ~ 400 Continuous (FEM/REM/CAC)
NAAQS Attainment Decisions	FRM/FEM	FRM/FEM/REM
Public Reporting (Air Quality Index)	~200 Continuous Monitors (issue with no defined acceptance of continuous methods)	~ 500 - 800 (FEM/REM/CAC)
Daily and sub daily mapping	~ 200 Continuous Monitors	~500 - 800 (FEM/REM/CAC)



# Conventional Generic PM2.5 Network

Monitor Type and Sample Frequency	Identified as Primary monitor for site	Samplers	Filters per Year (not including blanks)	Approx. Site visits per year	Allocated cost per year
FRM Daily	2	2	730	208	75,795
FRM 1 in 3	6	6	732	414	112,979
FRM 1 in 6	2	2	122	122	24,133
Supplemental FRMs 1 in 6	2	2	122	122	24,133
2 QA FRMs at 1 in 6	0	2	122	0	19,314
Continuous Monitors	0	2	0	0	11,974
Total	12	16	1828	866	268,328

10 Sites Required as FRM/FEM, 2 Supplemental Sites,  
Assume 15% collocated precision requirement

Daily monitoring requires ~104 sites visits per year, 1 in 3 ~69 site visits, 1 in 6 ~61 site visits



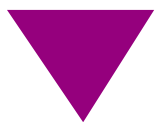
## REM Generic PM2.5 Network

Monitor Type and Sample Frequency	Identified as Primary monitor for site	Samplers/ Monitors	Filters per Year (not including blanks)	Site visits per year	Allocated cost per year
FRM as primary (1 in 3)	3	3	366	207	56,489
REM as primary	7	7	0	168	69,252
REM collocated at 3 sites with FRM	0	3	0	0	17,960
REM at 2 supplemental sites	2	2	0	48	19,786
1 QA FRM at 1 in 6	0	1	61	0	9,657
1 QA Continuous Monitor	0	1	0	0	5,987
Total	12	17	427	423	179,131

10 Sites Required as FRM/FEM/REM, 2 Supplemental Sites as REM,

Assume 15% collocated precision requirement

Assume 30% collocation of REMs for required sites - FRM is the primary monitor



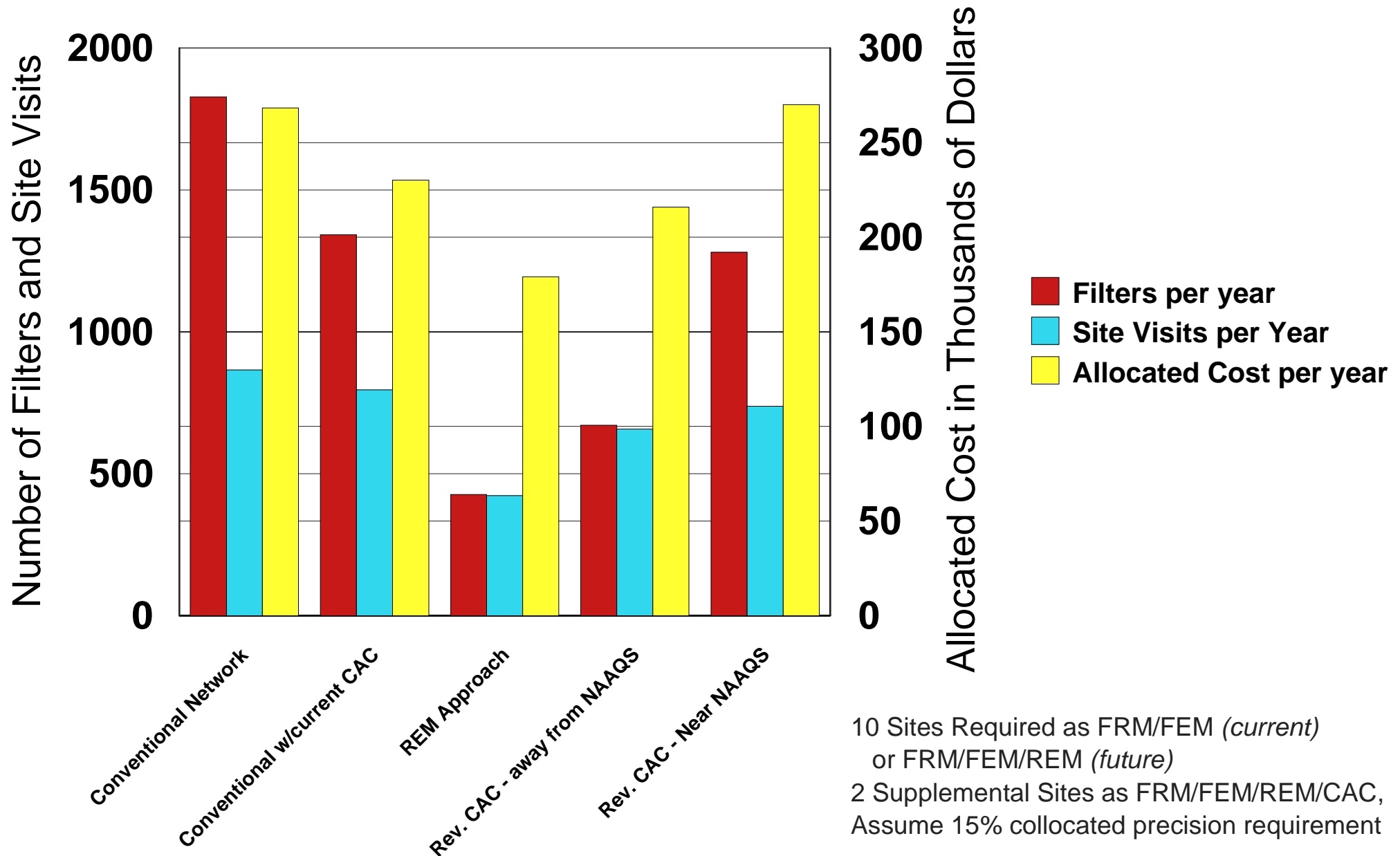
# Revised CAC Approach Generic PM2.5 Network

(significantly away from NAAQS)

Monitor Type and Sample Frequency	Identified as Primary monitor for site	Samplers	Filters per Year (not including blanks)	Site visits per year	Allocated cost per year
FRM as primary 1 in 6	10	10	610	610	120,665
CAC at required sites	0	10	0	0	59,868
CAC at supplemental sites	2	2	0	48	19,786
1 QA FRM at 1 in 6	0	1	61	0	9,657
1 QA Continuous Monitors	0	1	0	0	5,987
Total	12	24	671	658	215,963

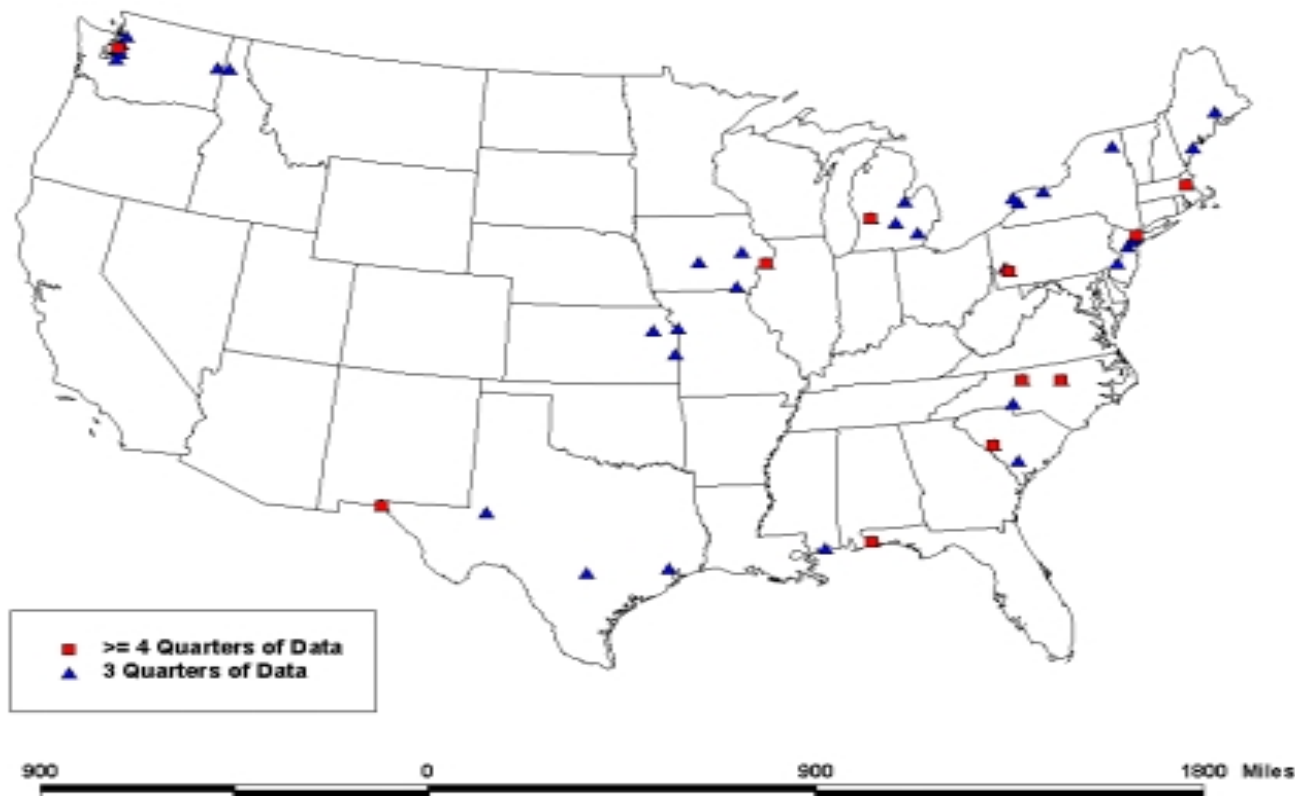
10 Sites Required as FRM/FEM or FRM/FEM w/CAC, 2 Supplemental Sites as CAC,  
Assume 15% collocated precision requirement

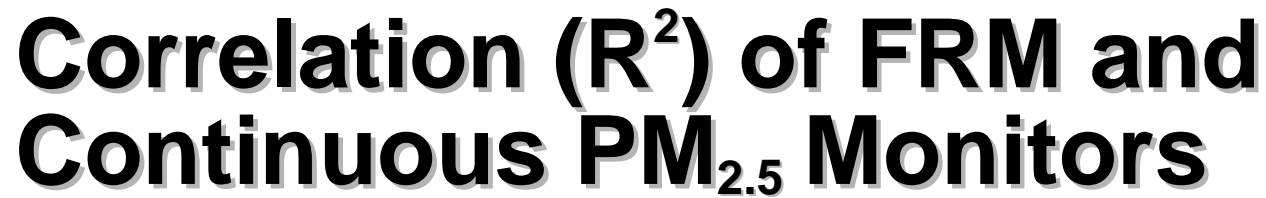
# Resource Summary of Generic PM2.5 Network Scenarios

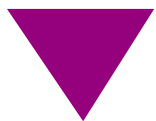


# PM2.5 Continuous Monitoring Data Analyses

- Correlation ( $R^2$ ) Map
- Scatterplots
- Seasonal bias by location
- Comparison of 160 PM2.5 FRM/FRM and 47 collocated FRM/Continuous sites to equivalency criteria

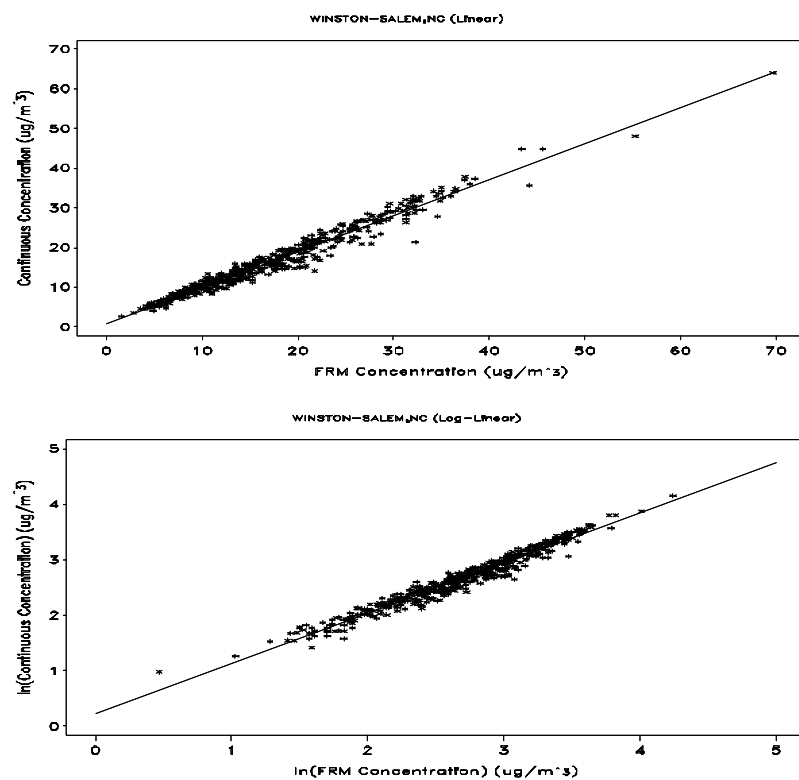




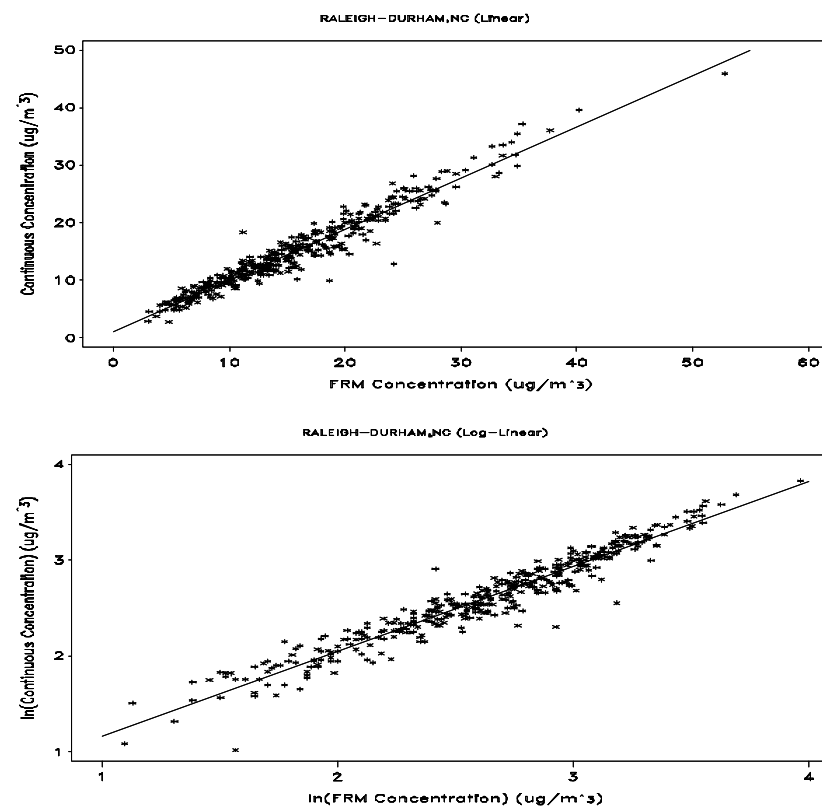


# Scatterplots of PM2.5 FRM/Continuous data

## Winston-Salem, NC



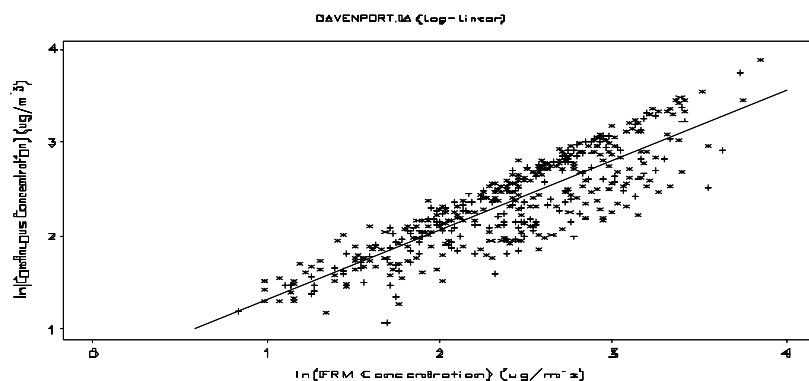
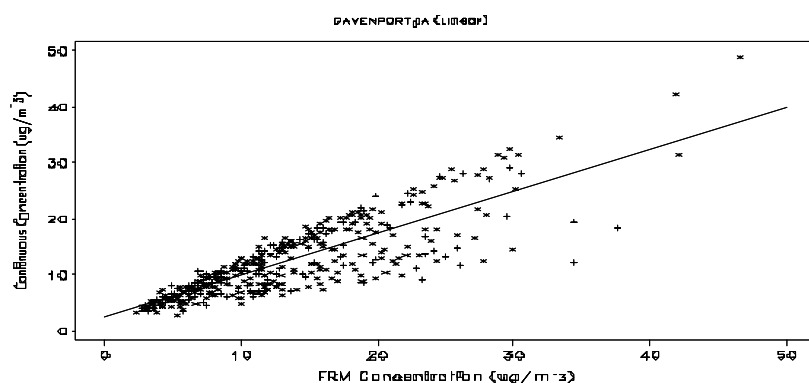
## Raleigh, NC



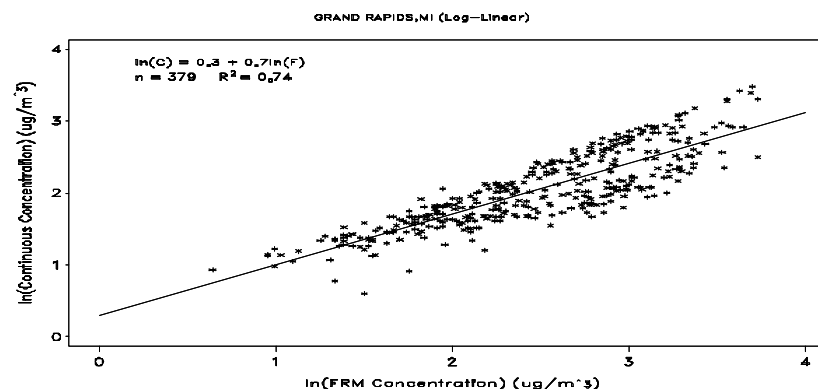
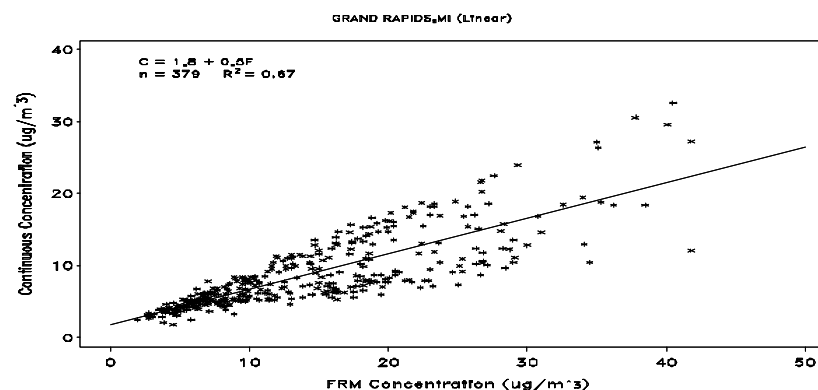


# Scatterplots of PM2.5 FRM/Continuous data

## Davenport, IA



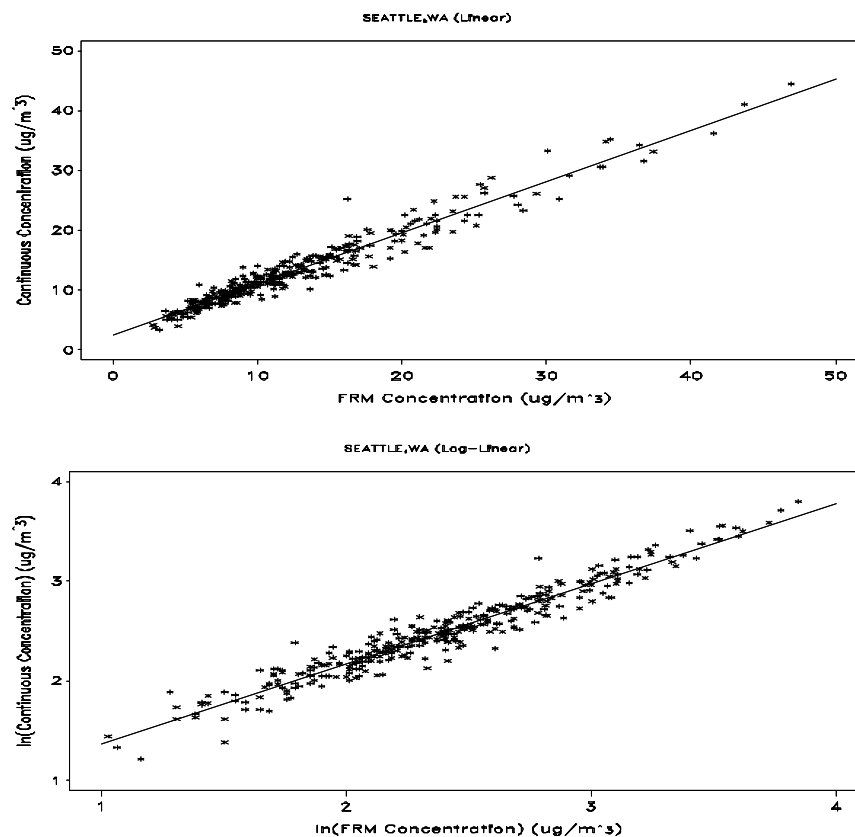
## Grand Rapids, MI





# Scatterplot of PM2.5 FRM/Continuous data

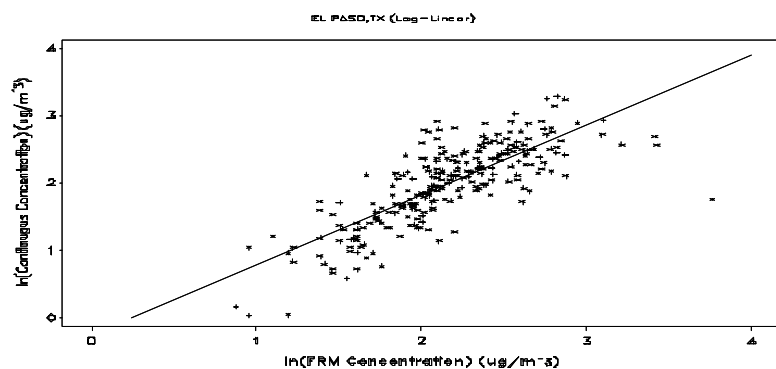
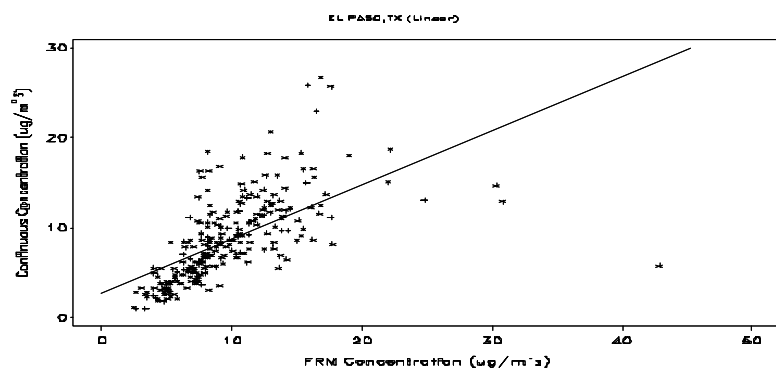
Seattle, WA



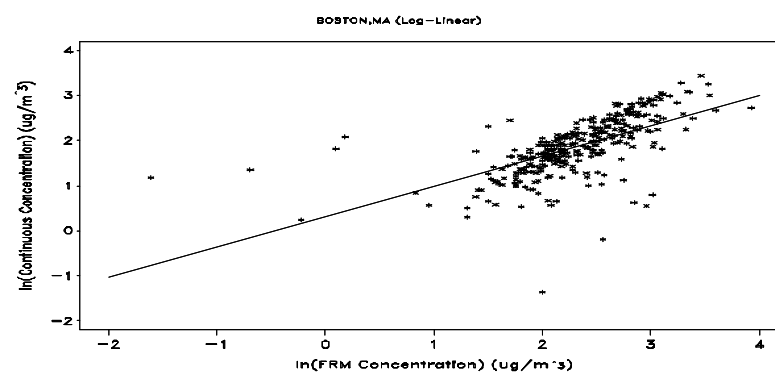
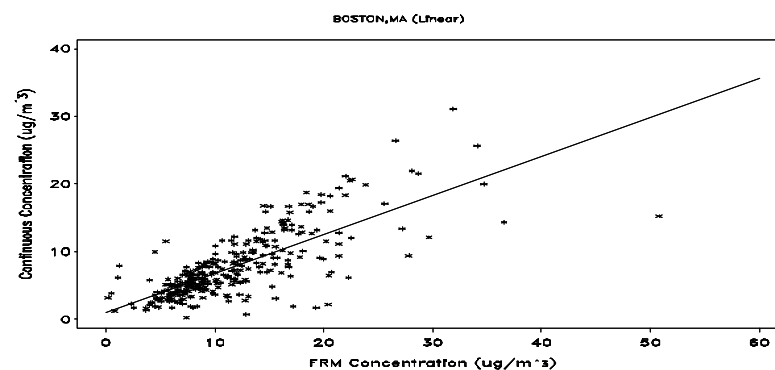


# Scatterplots of PM2.5 FRM/Continuous data

## El Paso, TX



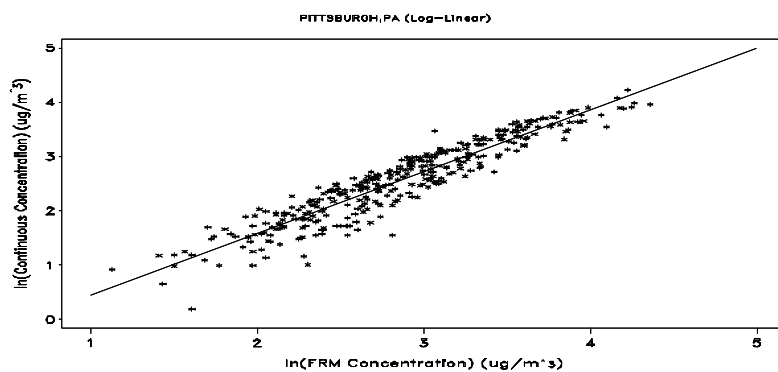
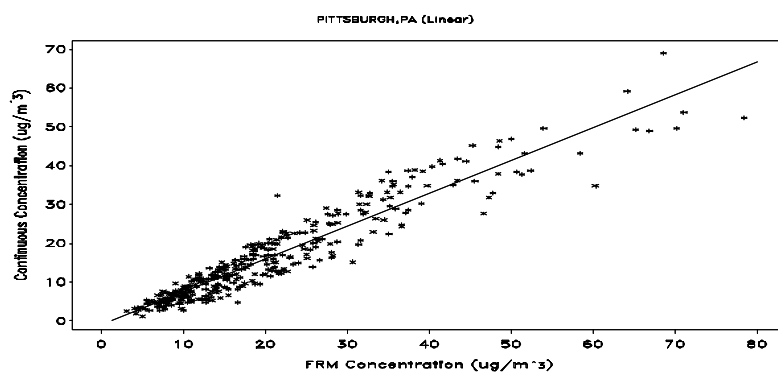
## Boston, MA



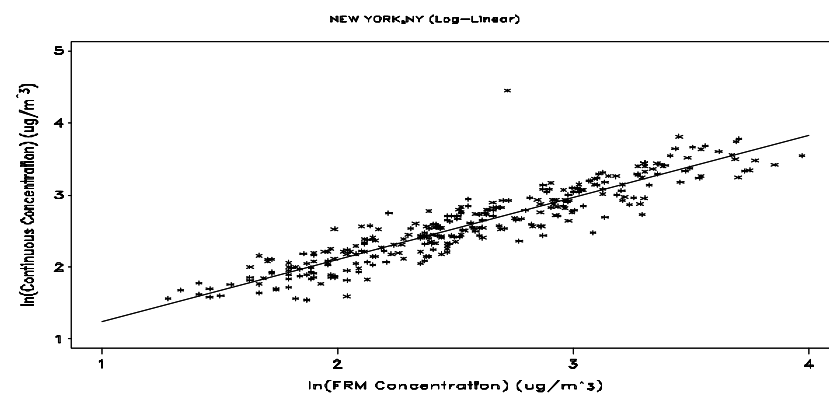
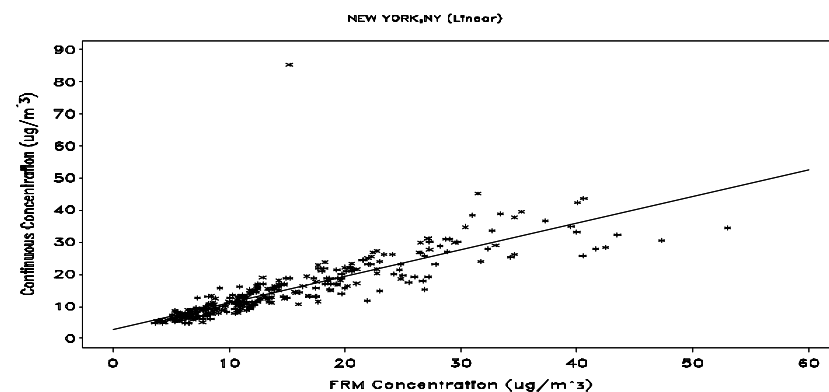


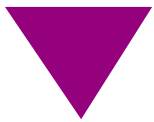
# Scatterplots of PM2.5 FRM/Continuous data

Pittsburgh, PA

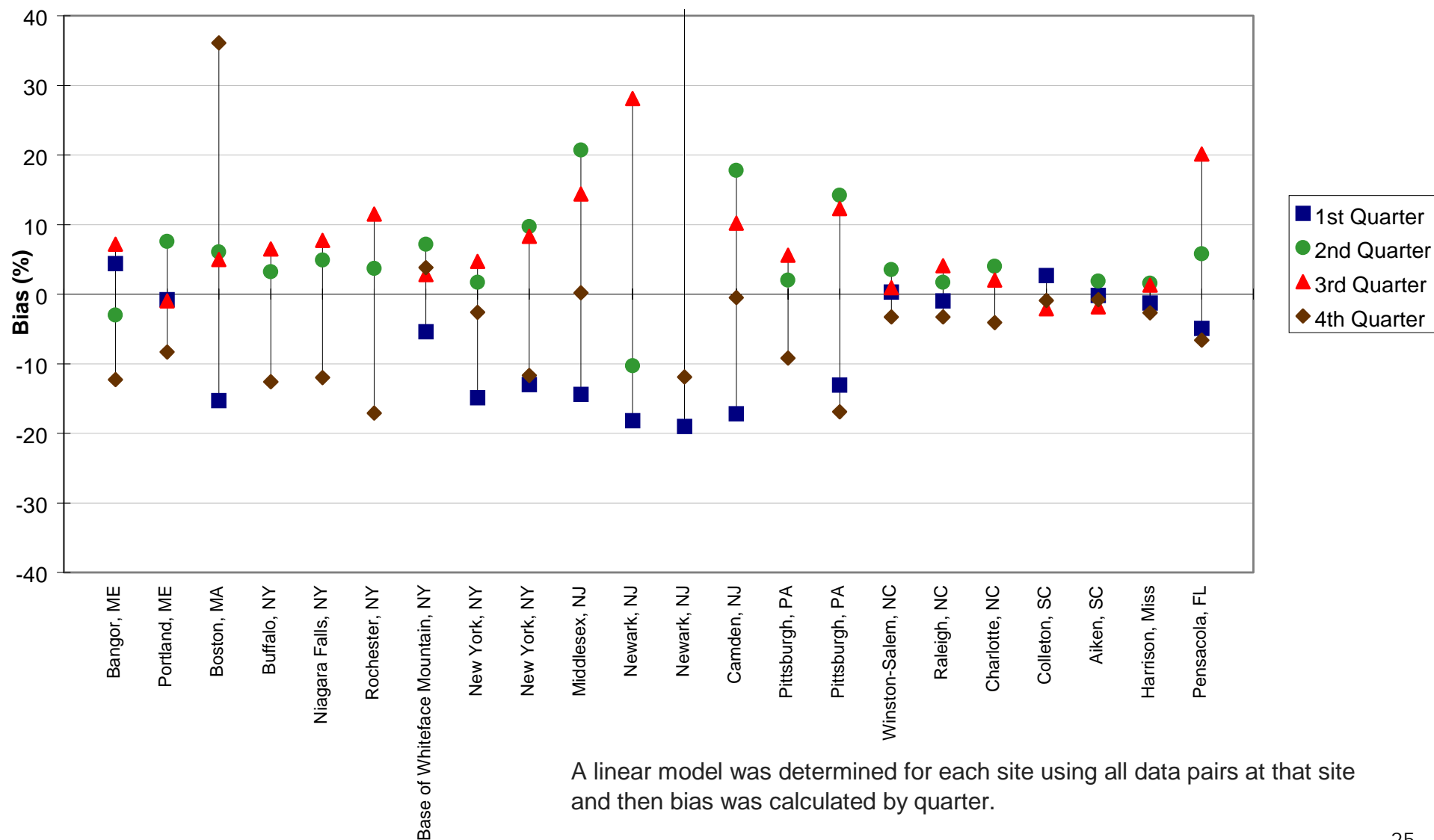


New York, NY



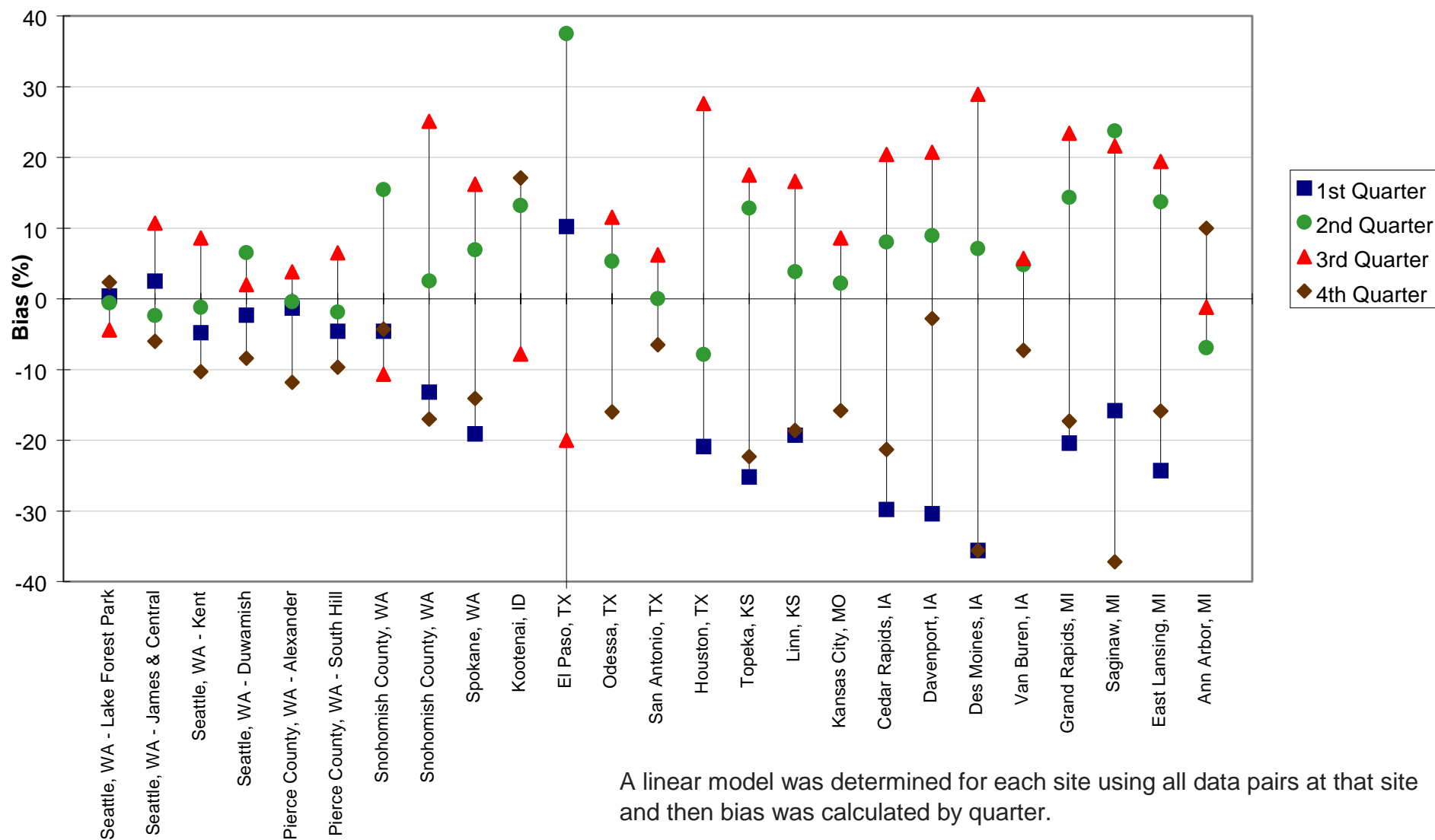


# PM2.5 Continuous/FRM Bias Data by Quarter Eastern United States





# PM2.5 Continuous/FRM Bias Data by Quarter Central and Western United States





# Comparison of Collocated FRM/FRM and FRM/Continuous sites to Equivalency Criteria

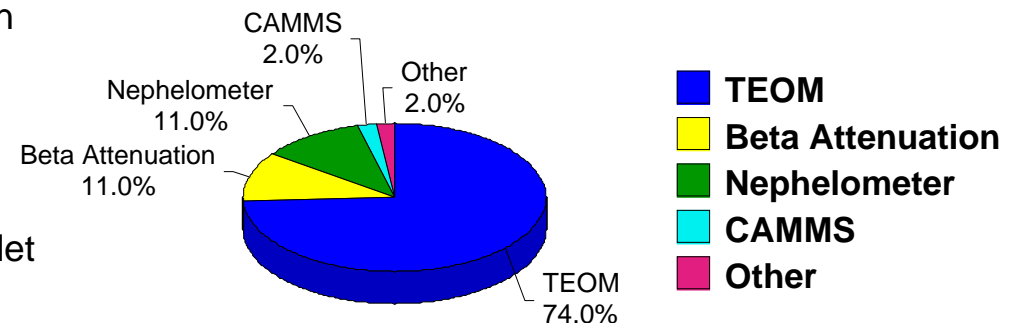
Criteria	160 Collocated PM2.5 Sites FRM/FRM (% of sites passing criteria)	47 Collocated PM2.5 Sites FRM/Continuous (% of sites passing criteria)
Precision 5%	28.1	0.0
Slope (1±0.05)	77.5	91.5
Intercept (+/- 1 ug)	82.5	97.9
Correlation (=>0.97)	66.2	10.6
Combined Equivalency Criteria	27.5	0.0

Each of the 47 collocated FRM/Continuous sites had its own linear model developed in this analysis

# PM2.5 Continuous Methods Summary

- 30 C TEOMs with Naphion dryer
  - limited data available
  - appears to be an improvement in capturing some of the volatiles
- 50 C TEOMs
  - lots of data available
  - working well where the aerosol is relatively stable year round
  - winter episodes in areas with volatiles can cause underestimation relative to FRM
- Beta Attenuation
  - limited data available
  - generally encouraging so far
  - Multiple vendors - Although most using Met One
- Nephelometers
  - limited data available
  - correlation's to FRMs are encouraging in areas used
  - Many potential vendors - Radiance Research used in WA State
- CAMMS
  - limited data available
  - Issues with mechanical failures

PM2.5 Continuous Monitors  
Estimated percent of the National Network





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# PM Continuous Monitoring Strategy Summary

- Need to move toward PM continuous monitors:
  - More robust data
  - More resource effective than filter based methods
- A hybrid network of FRMs and approved continuous monitors can meet multiple monitoring objectives:
  - NAAQS, AQI, Mapping, Exposure, Model Evaluation
- Flexible and rigid approach to acceptance of PM continuous methods based upon need of data for NAAQS decisions.
- Currently available continuous PM monitors may be suitable for many areas of the United States - Just not everywhere, all the time
  - Balance flexibility with needs for the quality of the data
- Data Quality Objectives can provide statistical criteria for acceptance of PM continuous methods